Year 1 | Constant Acceleration Equations

Constant Acceleration Equations | Formulae (Given In Formula Booklet)

The following equations may only be used when acceleration is constant.

s - Displacement, u = initial velocity, v = final velocity, a = acceleration, t = time

$$v = u + at \qquad s = \frac{1}{2}(u+v)t \qquad s = ut + \frac{1}{2}at^2 \qquad s = vt - \frac{1}{2}at^2 \qquad v^2 = u^2 + 2as$$

Even though they are in the formula booklet, it is helpful to memorise these equations.

No marks are given in the exam for *quoting formulae* – always substitute in known values.

Horizontal Motion | Example Problem Pairs

1E. A police car accelerates from $15\ \text{ms}^{-1}$ to $35\ \text{ms}^{-1}$ in $5\ \text{s}$. The acceleration is constant.

(a) Calculate the acceleration of the car.

(b) Find the distance travelled during the first 5 seconds.

1P. A car decelerates uniformly from $26.3\ \text{ms}^{-1}$ to $16.2\ \text{ms}^{-1}$, covering a distance of $240\ \text{m}$.

(a) Calculate the deceleration.

(b) Calculate the time taken to travel the $240\ \text{m}$.

2E. The driver of a car travelling at $60\ \text{mph}$ in mist suddenly sees a stationary bus $100\ \text{m}$ ahead. With the brakes full on, the car can decelerate at $4\ \text{ms}^{-2}$. Can the driver stop in time?

2P. A cyclist comes to the top of a hill $165\ \text{m}$ long travelling at $18\ \text{kmh}^{-1}$, and free-wheels down it with an acceleration of $0.8\ \text{ms}^{-2}$. Find how long he takes to reach the bottom of the hill, and how fast he is travelling.

Vertical Motion | Key Fact

- All objects in *'freefall'* accelerate towards the Earth with constant acceleration of $g \approx 9.8\ \text{ms}^{-2}$.
- When solving vertical motion problems *always choose a 'positive direction'*.

VERTICAL MOTION | EXAMPLE PROBLEM PAIRS

3E. A small ball is thrown straight downwards from a window $4.6\ \text{m}$ above ground, with an initial velocity of $1.2\ \text{ms}^{-1}$. Air resistance can be ignored.

(a) Calculate the time taken for the ball to hit the ground?

(b) Describe how your answer would change if air resistance was taken into account.

3P. Jill drops a stone into a well. A splash is heard $3\ \text{s}$ later.

(a) Calculate an estimate of the depth of the well.

(b) State one assumption have you made about the forces acting on the stone.

Hint: Consider the initial velocity of an object that is 'dropped'.

4E. A ball is thrown vertically upwards from ground level with initial speed $20\ \text{ms}^{-1}$.

(a) Calculate the maximum height reached by the ball.

(b) Find the time from release when the ball is at a height of $12\ \text{m}$ and travelling downwards.

4P. A ball is projected vertically upwards. The maximum height reached by the ball is $78.4\ \text{m}$.

(a) Calculate the initial speed of the ball.

(b) Find the times at which the ball is at a height of $40\ \text{m}$.

(c) Hence find the time for which the ball is more than $40\ \text{m}$ above the ground.

5E. A stone is thrown upwards with a velocity of $6\ \text{ms}^{-1}$, from a platform $1.2\ \text{m}$ above the ground. Find the velocity of the stone when it hits the ground.

Use $g = 10\ \text{ms}^{-2}$ giving your final answer to an appropriate degree of accuracy.

5P. A boot is thrown vertically upwards from a point x metres above the ground. Its speed of projection is $4\ \text{ms}^{-1}$. The boot lands on the ground 2 seconds after being thrown.

Find the value of x.